The IRAS Galaxy Atlas (IGA)
Final Report
NASA/Goddard Contract   NAS5-32642

PI: Thomas A. Prince, Caltech
December 15, 1999

After its launch in 1983, IRAS conducted the first all-sky survey of infrared emission, and fundamentally changed our view of many astrophysical phenomena including star formation, Galactic structure, and galaxy evolution. IRAS remains the only full-sky infrared sky-survey obtained to date and thus represents a unique data set for astronomical research.

Shortly after the IRAS mission, an atlas of the entire sky was produced, having a resolution of about 5 minutes of arc (about 1/12th of a degree). This atlas was produced using straightforward image processing algorithms. In the late 1980's it was realized that more sophisticated algorithms could extract considerably better spatial resolution from the data, as fine as 1 minute of arc (1/60th of a degree), allowing resolution of features 25 times smaller in terms of angular area. These algorithms were based on maximum entropy and maximum correlation techniques, and were computationally much more intensive than the algorithms used to produce the original IRAS sky atlas. One widely used algorithm was the HIRES algorithm [1].

The computational demands of the advanced image processing algorithms prevented their widespread applications to the IRAS data and also the production of a new IRAS sky atlas with greatly improved angular resolution. Recognizing this fact, in 1993 we proposed a project to NASA having the goal of producing a new infrared map of our Galaxy. In particular, we proposed to reprocess the IRAS data taken in the early 1980's using modern image processing algorithms and the large Intel parallel computers of the Center for Advanced Computing Research (at that time called the Caltech Concurrent Supercomputing Facilities - CCSF). The rationale was simple: what took approximately 100 days on a typical workstation would take less than a day on the multi-processor parallel computers, thus making a high-resolution infrared atlas of the Galaxy feasible.

The first attempt to process a large (6 degree x 6 degree) field with the higher resolution was a technical success but an aesthetic failure. While we clearly demonstrated high resolution, high efficiency and high throughput using parallel computers, the resulting image of a molecular cloud complex in the constellation of Ophiuchus did not look particularly good. Although the HIRES image processing algorithm had worked well on small-size fields, the large Ophiuchus image showed numerous distracting large-scale artifacts, in particular prominent "stripes" due to changes in the gain and background of the IRAS detectors from orbit to orbit. To solve this problem, Caltech graduate student Yu Cao developed a new image processing algorithm considerably more robust in suppressing artifacts such as stripes [2]. Using the new algorithm we proceeded with the production of an atlas at 60 and 100 microns which included an band 5 degrees on both sides of the Galactic plane, as well as the Orion, Ophiuchus, and Taurus-Auriga molecular clouds. We then applied the algorithm to the full 60 and 100 micron IRAS Galactic plane data set to construct a comprehensive atlas of images of the Galaxy.

The IRAS Galaxy Atlas (IGA) has been a collaboration between the Center for Advanced Computing Research (CACR) and the NASA/JPL Infrared Processing and Analysis Center (IPAC). Drs. Sue Terebey and Chas Beichman of IPAC were key contributors to the project. The IRAS Galaxy Atlas (IGA) was completed and was delivered to IPAC for distribution to the entire astronomical community [3,4]. The Infrared Science Archive (IRSA) has continuing responsibility for archiving, maintaining, and distributing the IGA to the astronomical community and the atlas can be accessed at [4].

With its considerably higher spatial resolution the IGA images have been used in conjunction with high-resolution radio surveys to undertake broad-band multi-wavelength studies of star forming regions containing young stars and supernova remnants. We anticipate significant additional science from the IRAS Galaxy atlas for years to come. Examples of science undertaken by members of the IGA project are described in [5,6,7,8].

A modest amount of additional work was performed to investigate possible improvements to the image processing algorithms. Results of one of these investigations is discussed in [9]. In addition, studies of the so-called "pixon algorithm"

were also undertaken as a comparison to the HIRES algorithm used in the production of the IGA.

[1] Aumann, H.H., Fowler, J.W., & Melnyk, M., Astronomical Journal, 99, 1674 (1990).

[2] Cao, Y., Prince, T.A., Terebey, S., & Beichman, C.A., "Parallelization and Algorithmic Enhancements of High-Resolution IRAS Image Construction", Pub. of the Astronomical Society of the Pacific, 108, 535 (1996).

[3] Cao, Y., Terebey, S., Prince, T.A., & Beichman, C.A., "The High Resolution IRAS Galaxy Atlas" Ap.J.Suppl., 111, 387 (1997).

[4] http://irsa.ipac.caltech.edu

[5] Wallyn, P., Mahoney, W.A., Corbel, S., Cao, Y., Durouchoux, P., and Vilhu, O., "Millimeter and Infrared Observations of SGR 1806-20", Astrophy. & Sp. Sci., 231, 89 (1995).

[6] Meyer MH, et. al., "A Massive Cometary Cloud Associated with IC 1805", Ap.J., 464, L175 (1996).

[7] Noriega Crespa, A., Van Buren, D., Cao, Y., and Dgani R., "A Parsec-Size Bow Shock Around Betelgeuse", A.J., 114, 837 (1997).

[8] Heyer, M.H. and Terebey, S., "The Anatomy of the Perseus Spiral Arm: (CO)-C-12 and IRAS Imaging of the W3-W4-W5 Cloud Complex", Ap.J., 508, 721 (1998).

[9] Cao, Y., Eggermont, P.P.B., and Terebey, S., "Cross-Burg Entropy Maximization and its Application to Ringing Suppression in Image Reconstruction", IEEE Trans. Image Proccess., 8, 286 (1999).